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NAGW-3571, PI Jane Charlton

The Theory of QSO Absorption Line Systems and Their Relationship to Galaxies

The fundamental goal of this effort is to paint a picture of what the Lyα forest clouds are and how they are distributed in space. Progress during the first phase of this program involved development of the "Cheshire Cat Model" of Lyα clouds in which systems over a large range of column densities are produced by disks with somewhat smaller column densities than those of normal galaxies. A prediction of the slab model of Lyα clouds (Charlton, Salpeter, and Hogan 1993) was confirmed by a new observational result (Petitjean et al. 1993), and the comparison of models to the new data allowed an estimate of the pressure of the intergalactic medium. This result should be forthcoming in preprint form within the next month. The various results will now be described in more detail.

The most important result of this effort to date is the measurement of the pressure of the intergalactic medium in the context of the equilibrium slab model of Lyα clouds. Clouds may be confined both by self-gravity and the gravity of a dark matter halo and by the pressure exerted by a hot intergalactic medium. A transition between the regimes of pressure and gravity confinement is expected to produce a change in the slope of the distribution of the number of clouds as a function of neutral column density. Such a break in the neutral column density distribution has recently been reported by Petitjean et al. (1993). If the slope in the pressure confined regime is set by the data, the slope in the gravity confined regime can be predicted by the models and is found to be consistent with the observed slope. The neutral column density at which the transition occurs (around $10^{16}\mathrm{cm}^{-2}$) can be used to derive a value of the pressure. This derivation depends on the amount and distribution of dark matter, but values of P_{IGM}/k are in the range 5-25 cm^{-3}K at a redshift of 2.5. It is of interest to note that this is within an order of magnitude of the upper limit on the pressure based on the COBE y parameter.

Penn State graduate student, Suzanne Linder began work on this project in May 1993. She is working primarily on the "Cheshire Cat Model" mentioned above. There are various reasons to think that the Lyα clouds are in a slab, rather than a spherical geometry. Although it is clear, from considerations of the large number and lack of clustering, that forest clouds do not arise from the disks of normal spiral galaxies, it is not clear to what extent they might resemble galaxies. This effort is based on the idea (Salpeter 1993) that extended disks (eg. 250 kpcs in radius) form early in dark matter halos (as in normal spirals). However, the central column density of these systems is typically a factor of ten less than a normal spiral, and star formation does not readily occur. The neutral column density of the central part of this structure can produce damped Lyα absorption, the intermediate radii can produce Lyman limit systems, and the outer parts can lead to Lyα forest clouds. It is expected that at least some of these systems will eventually form stars, but that this period of star formation will be truncated because of winds, fountains, and the smaller gravitational potential well as compared to normal disks. (During the next year, connections with the faint blue galaxies will be explored in more detail.)

In the context of the Cheshire Cat Model, the transition between pressure and gravity confined regimes can be used to set the IGM pressure, as in more general slab models above.

An illustration of a model fit to the Petitjean et al. (1993) data is given in Figure 1. The amount of dark matter distribution is given by the rotation velocity, and the properties of the disk as a function of radius can be derived and compared to the observations of the various types of Lyα clouds. This calculation includes the vertical structure of the disk, and the effect of extinction which is important when considering the properties of clouds that are optically thick or nearly so. Preliminary results seem to be consistent with the observations in the Lyman limit. This work will soon be related to observations of the sharp HI edges of galaxy disks. During the next year, these models will be explored in much more detail, with focus on predictions for the damped Lyman-alpha clouds, and consideration of the effect of an oblate dark matter halo. The population of Cheshire Cats will be considered in conjunction with the population of known galaxies to see if consistency will observations of the Lyα clouds can be achieved.

Work continues on the idea that there is a natural cut-off expected at the low end of the column density distribution of forest clouds. The physical mechanism behind this is evaporation of clouds due to thermal conduction. A better understanding of the circumstances in which clouds are in the classical and saturated regimes will allow a more accurate calculation of this effect, and a comparison with the data.

References

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Petitjean, P., Webb, J. K., Rauch, M., Carswell, R. F., & Lanzetta, K. 1993, MNRAS, 262, 499

Salpeter, E. E. 1993, AJ, 106, 1265

Caption to Figure 1

This is a plot of the number of Lyα clouds as a function of the observed neutral hydrogen column density. The points are taken from Petitjean, et al. 1993. Error bars in the number are Poisson errors, while errors in the column density indicate the bin size. The solid line represents the prediction of a Cheshire Cat Model, normalized to the data. A single power law does not fit this data as well.

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